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M456 BOOM/BODY DISASSEMBLY

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This report covers the exploratory engineering effort to determine the feasibility of disassembling the boom from the body of the standard M456 HEAT projectile in preparation for reconditioning field stock.

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FORWORD

The Vehicle Fired Munitions Section, of the Munitions Systems Division wishes to express its appreciation to the Propulsion Test Section of the Technical Services Division, especially Joseph Derk, for its assistance in the exploratory work accomplished at ARRADCOM that is covered in this report.

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INTRODUCTION

By 1977, more than half of the cartridge, 105-mm, HEAT, M456A1 and M456E1 in field stock had been placed in restricted use because of ammunition malfunctions. Many options of correcting the malfunctions were considered; complete remanufacturing of all the stock appeared to be the most attractive approach. The remanufacturing process would not only remove many potential malfunctions, but would also update the round performance by including a full-frontal area impact switch (FFAIS) and a modified fuze. To completely remanufacture the cartridge economically, however, the aluminum boom would have to be disassembled from the steel body of the projectile without damage, so it could be salvaged for reuse.

The boom/body threads are coated with a high strength sealant when the cartridge is assembled. Upon curing, the shear strength of the sealant becomes so high that it usually requires 677.9 to 135.8 joules (500 to 1,000 ft/lb) of torque to break the joint at room temperature. This can easily result in unacceptable damage to the metal parts during disassembly.

Experimentation with empty metal parts assembled with the sealant has shown that it takes 177°C to 240°C (350°F to 400°F) to deteriorate the sealant sufficiently to permit reasonable disassembly torques. These are unsafe temperatures for an HE-loaded projectile, such as those in stock.

The avoidance of damage to the metal parts intended for reuse is obvious. Hazard to the explosive load can take many forms. The Composition B explosive may be directly initiated. The fuze may function which would in turn initiate the explosive. Heating the metal parts may melt the explosive and cause RDX separation that could lead to a premature initiation during gun firing, or an excessive rise in boom temperature may initiate the tracer.

It became clear that a safe, nondestructive method of boom/body disassembly must be developed before complete remanufacturing of the stockpile could be considered. The evolution of the method sought follows.

METHOD

Sample Preparation

Four standard bodies (dwg 10521644) and standard fin-boom assemblies (dwg 8597611) were prepared as test samples (fig. 1).

a. The boom was bit drilled (no. 38) to allow a thermocouple to be inserted within 3.30 mm (0.130 in.) of the boom/body thread.

b. The body was bit drilled (no. 38) for two thermocouples, one at the base of the explosive cavity within 11.18 mm (0.44 in.) of the fuze location, and one immediately forward of the rear bourrelet within 2.92 mm (0.115 in.) of the explosive cavity.

c. The boom/body threads were completely coated with sealant (laminac, dwg 10523979) and assembled with 76.25 to 79.07 joules (675 to 700 in./lb) of torque per drawing 8861071, and allowed to cure.

d. Five thermocouples were installed on each test sample (fig. 2). One was installed in each of the three drilled holes described above, one in the fuze well wire slot, and one in the tracer cavity of the fin. The thermocouple in the tracer cavity was installed only during the time the heat guns were used, as described later.

e. The forward portion of the body was transversely bit drilled (33/64 in.) to accommodate a 12.7-mm (1/2-in.) rod. The protruding rod was for the convenience of counteracting the high test torques applied to the boom.

f. The fin was sealed and pinned to the boom to prevent its movement during torque test.

The body did not contain a filler, consequently, there was no filler to serve as a heat sink. This worsened the explosive cavity temperatures during the flameless torch application.

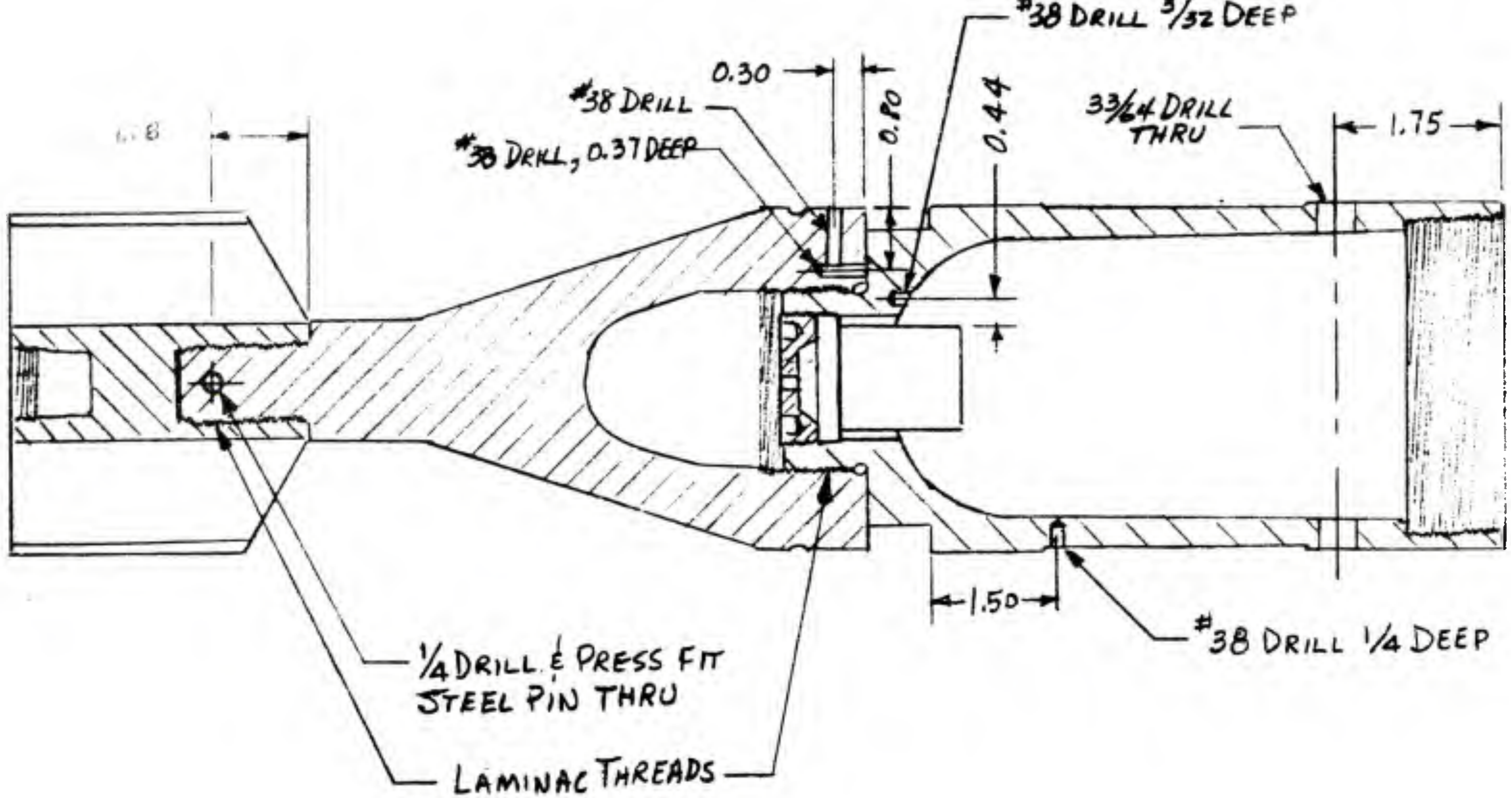

Figure 1. M456 Metal parts preparation.

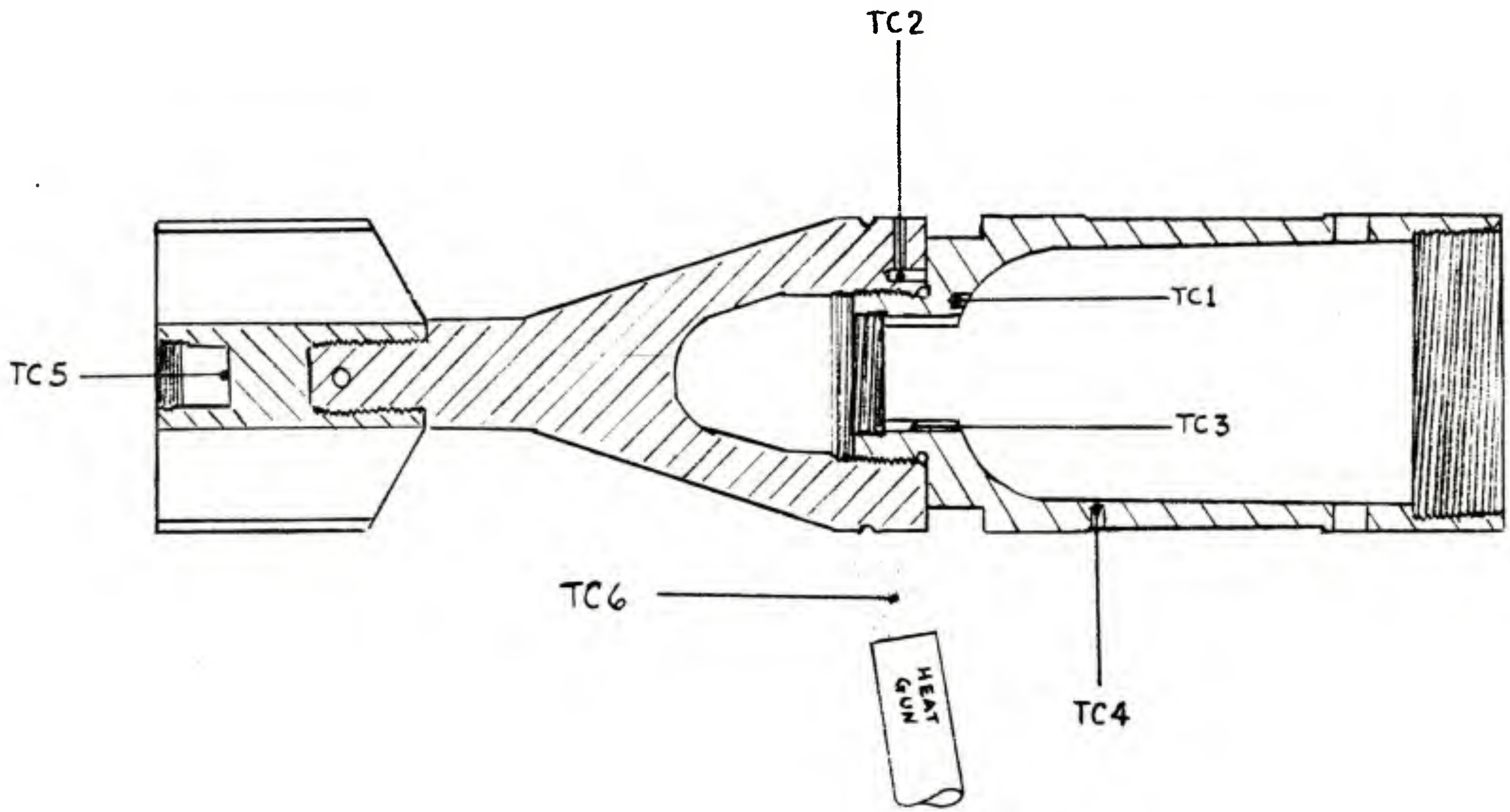

Figure 2. Thermocouple locations.

Unsuccessful Procedures

The unsuccessful attempts to disassemble the sealed and torqued booms from the body will be very briefly described.

Hot Water

The boom of the assembly was completely submerged in boiling water generated from high pressure steam. The intent was to make the sealant sufficiently pliable to reduce the shear strength. Disassembly was attempted at temperatures up to 93.3°C (200°F), as recorded by the thermocouple in the wire slot, but the boom/body joint could not be disassembled by torques estimated to exceed 474.5 joules (350 ft/lb).

Dry Ice

The test samples were packed in dry ice to create high embrittlement within the sealant and lower the shear strength to an acceptable torque value. Again, the joint could not be disassembled by torques estimated to exceed 474.5 joules (350 ft/lb).

Dry Ice and Hot Water

The samples were packed in dry ice, then removed and completely submerged in boiling water to create a thermal shock between the aluminum boom and the steel body. It was envisioned that the sudden expansion of the boom would cause a separation at the thread interface, fracturing the sealant. Once again, torques estimated to be in excess of 474.5 joules (350 ft/lb) were applied with unsuccessful results.

Although thermal shock was a failure, engineering judgement and experience suggested that it held the greatest promise of success.

Successful Procedures

It was found that the bond of the thread sealant between the boom/body threads of an explosive-loaded projectile could best be overcome by introducing substantial thermal shock across the thread interface.

Using inert metal parts assembled as described under Sample Preparation, thermal shock was produced by impinging an intense flame from an acetylene (Prestolite) torch on the boom, opposite the thread area. The boom could be disassembled with 271.2 to 338.9 joules (200 to 250 ft/lb) of torque. This method approaches acceptable torque values for an extensive ammunition reworking operation.

The use of an open flame on HE-loaded rounds is hazardous. Consequently, an alternate method was sought to produce the same intense thermal shock to the metal parts. After evaluating several considerations, it was concluded that flameless (electric) heat guns offered the best chance of success

The equipment used for this approach was:

a. Four Sylvania, Serpentine gas/air heat torches, series III, part number CGH117558, with outer shields.

b. Four copper-constantan thermocouples.

c. Four Doric transducers 400A type T/°F to read the thermocouple output directly in degrees Fahrenheit.

d. One 406.7 joules (300 ft/lb) torque wrench with fin adapter.

e. A 413.685 kPa (60 psi) regulated air source.

f. Four 02.51 mm (0.099 in. dia) orifices for air flow control.

g. A 220 vac, 17 kw minimum power source.

h. A control module for air and electric power.

The four sample projectile metal parts were assembled as described under Sample Preparation.

Previous experience with the acetylene flame method revealed that thermocouples TC1 and TC4 detected only an insignificant rise in temperature during the experiment. Therefore, during the heat gun method of heat application, these two thermocouples positions were frequently eliminated. One additional thermocouple, TC6, was placed directly in the hot gas stream of a heat gun to monitor the gas temperature.

Three prepared metal parts were placed vertically in a simple holding fixture at room temperature. The thermocouples mounted in the metal parts assembly were connected to their respective display instruments.

The four heat guns were trained on the boom in the area of the crimp groove with the gun nozzle located about one inch from the boom. Air and power were turned on to the control module, shown schematically in figure 3. Through the module, air and power were supplied to the heat guns.

With the adapter and torque wrench connected to the fin assembly, torque was applied until breakaway occurred. Then the torque was continued until the boom was removed. The heat guns were turned off during the last 10% of thread engagement.

The pronounced temperature difference reflected in table 1 between the boom and the adjacent fuze well of the body can be attributed to two causes. One is the relatively low thermal conductivity of the steel body compared to the aluminum boom. The other is that heat transfer is reduced significantly once the abutting surfaces begin to separate in the disassembly process. This effect is observed in the data by comparing the measurements of thermocouples TC2 and TC3. This procedure is obviously successful and apparently quite safe.

The highest temperature experienced by the projectile body, explosive, fuze and tracer is below the upper service temperature 51.7°C (125°F) for the cartridge. In fact, hundreds of rounds have been safely fired at 62.8°C (145°F).

The complete cycle time for disassembly is much less than one minute.

CONCLUSIONS AND RECOMMENDATIONS

The boom can be removed from the body of the M456A1 projectile with predictable safety and without damaging the metal parts.

A suitable clamping fixture must be developed to hold the HE-loaded, assembled projectile.

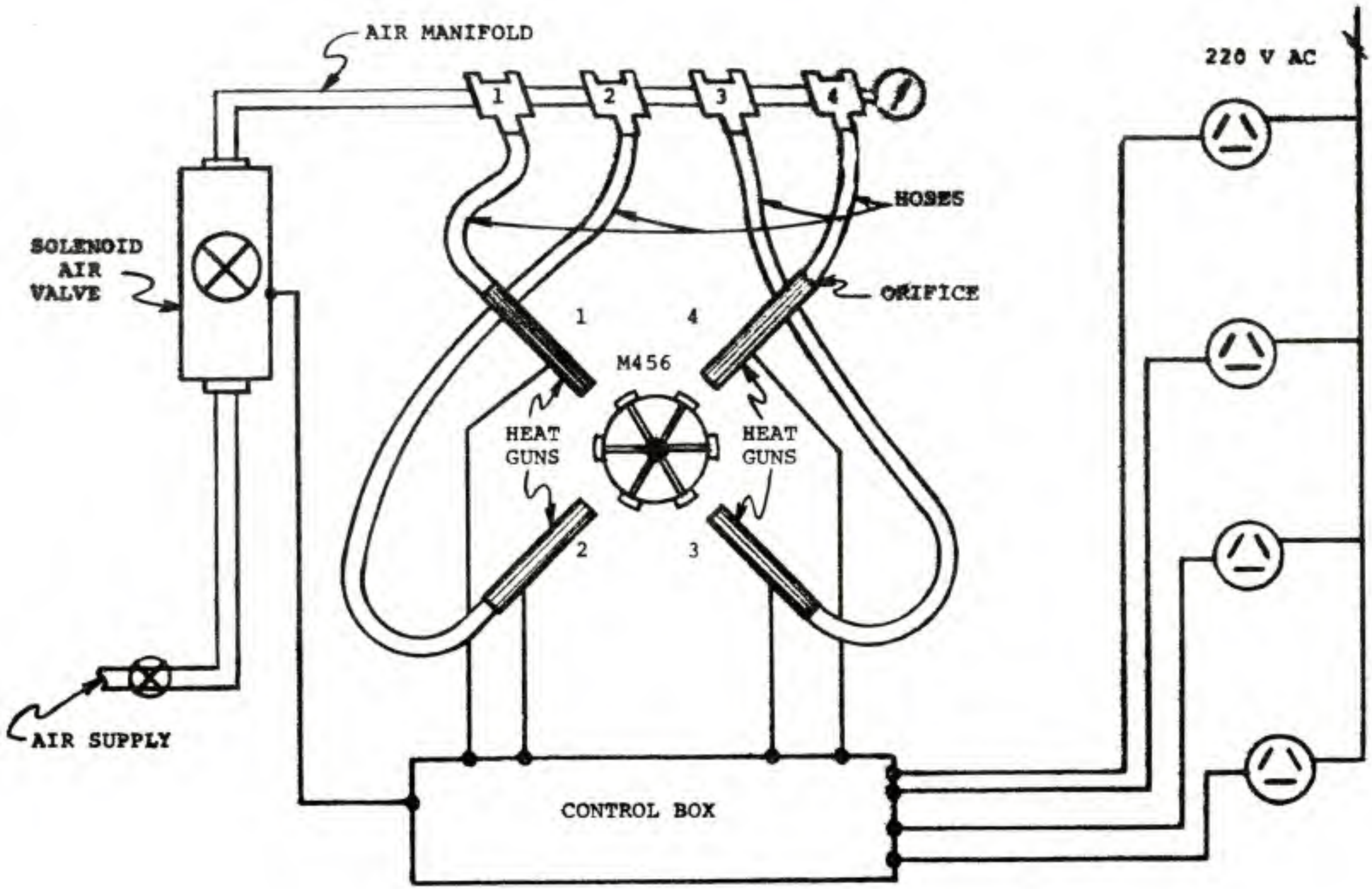

Figure 3. M456 Boom removal layout schematic.

Table 1. M456 Boom/body disassembly with flameless heat gun

Test no.	Maximum temperature Boom thread, TC2 °C (°F)	Body fuze well, TC3 °C (°F)	Explosive cavity, TC1 °C (°F)	Tracer cavity, TC5 °C (°F)	Torch gas, TC6 °C (°F)	Boom torque J (ft/lb)	Heating time (sec)	Remarks
1	121.1 (250)	48.9 (120)	<43.3 (<110)	- -	593.3 (1100)	271.2 (200)	45 -	
2	86.1 (187)	39.4 (103)	<37.8 (<100)	- -	621.1 (1150)	203.4 (150)	35	
3	97.8 (208)	43.3 (110)	- -	27.8 (82)	- -	217.9 (160)	40	
				34.4 (94)			None	After 3 min
				43.3 (110)			None	Stabilized 15 min

The heat gun system, used and described herein, should be refined if considered for any future application. For example, perhaps five or six heat guns would increase the thermal gradient, reduce the torque requirement, reduce the time cycle, and possibly reduce the net heat transferred to the body.

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